Chapter 8. Capitol Reef National Park

Introduction

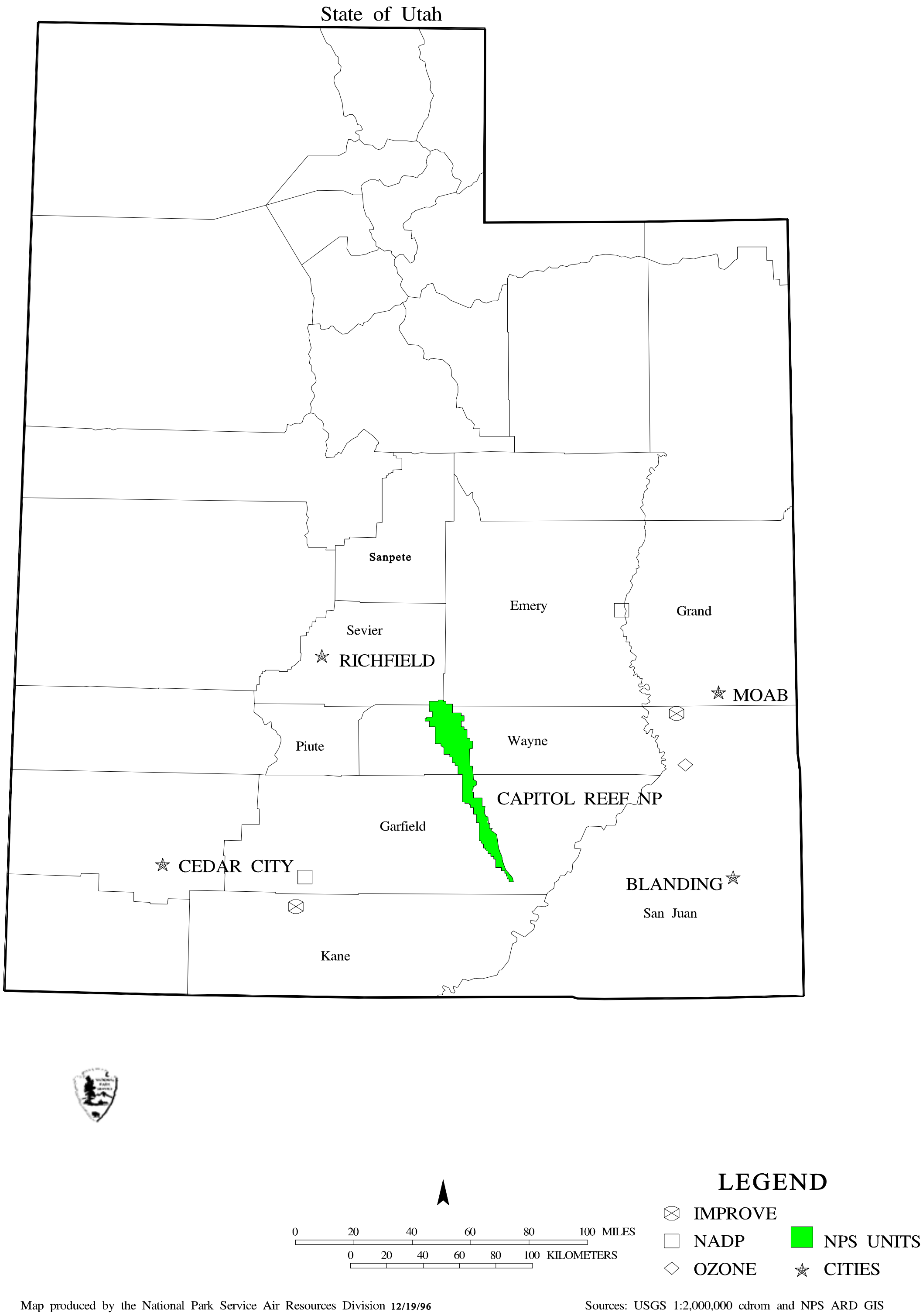
Capitol Reef National Monument was added to the Department of the Interior list of National Monuments in 1937. The monument was expanded to 97,940 ha in 1971 and given National Park status. Today, all but 7100 ha of the 97,940 ha are federally controlled. Capitol Reef National Park is located in south central Utah, and runs north from the Glen Canyon National Recreation Area over 160 km to Cathedral Valley Junction (Figure 8-1). The Park is bordered to the northwest by the Fishlake National Forest, to the southwest by the Dixie National Forest and to the south by the Glen Canyon National Recreation Area. The Park lies in Wayne, Garfield, Sevier and Emery Counties.

The Park was originally established for the remarkable geology of the area. The Waterpocket Fold is a dramatic 160 km monocline, capped primarily by Navajo Sandstone from the Jurassic Period. The extensive folding and erosion has developed a large number of arches and natural bridges, narrow high walled canyons, and large rock domes (from which the name of this park is derived). Archeological sites from the Fremont People are abundant, along with recent historical sites of early Mormon pioneers who settled the region in the late 1800's.   Elevation in Capitol Reef National Park ranges from below 1600 m where the Fremont River leaves the Park to 2800 m in the northwest end of the Park near Hartnet Junction. The Park has the best developed and most abundant rock pools of the Colorado Plateau.

Geology and Soils

The oldest sedimentary layers of the Waterpocket Fold were deposited in the Permian Period in a variety of environments. Small outcrops of Cutler Sandstone are the oldest strata visible in the Park, formed during a desert period. Kaibab Limestone layers (the Kaibab formation comprises most of the top layer in the Grand Canyon) sit atop the Cutler, indicating sea encroachment on the ancient desert with no erosional unconformity. The Moenkopi Formation developed in a variable, shallow-sea setting in the Triassic Period, with alternating textures of mudstone, siltstone, and sandstone, mixed with a few limestone strata.   The gray and blue Chinle Formation is comprised of mudstone and shale material that weathers into smectite clays with shrink/swell properties (often called bentonite). These “badland” desert systems are sparsely vegetated because plants have difficulty in the easily eroded, shrinking and swelling soils. The major formations of the Park were

Figure 8-1. Location of Capitol Reef National Park.



deposited after the late Triassic. The Wingate Sandstone formed in a huge desert, which was then replaced by a river floodplain that deposited the Kayenta Siltstone. The Navajo Sandstone was deposited in another desert in the Jurassic Period. Younger formations include the Entrada Sandstone and Cutler Formation, deposited on floodplains and tidal flats, and the youngest Jurassic strata, the Morrison Formation that contains major deposits of dinosaur fossils. A thin layer of Dakota Sandstone deposited in the Cretaceous is topped by massive deposits (1000 m thick) of Mancos Shale. The Mancos Shale weathers into barren, badland soils. The Cenozoic Era has been primarily erosional as a result of the regional uplift (Chronic 1988).

No soils mapping is available for Capitol Reef National Park, but soil formation depends heavily on the parent material. All soils should be relatively high in pH (low in acidity), and very resistant to acidification from acid deposition due to the characteristics of the parent material.

Climate

The climate of Capitol Reef National Park varies with season and elevation. Weather records are scarce for most of the Park; lower elevation sites probably average about 125 mm of precipitation annually, compared with 300 mm at higher elevations. The Park headquarters at Fruita averages about 180 mm/yr, with one third falling in July and August and most of the rest during winter months. Temperature extremes range from -8 ^{o}C in winter to over 38 ^{o}C during summer.

Vegetation

Capitol Reef National Park contains six major vegetation communities, and each type can be subdivided into distinct minor communities. The Badlands Community is found on the most severe, low elevation sites in the Park. Substrates tend to be saline and include the clay rich, poor quality soils derived from the Mancos Formation and the gypsiferous soils derived from the Carmel and Moenkopi Formations. Species occurring in this type include saltbush (*Atriplex* spp.), buckwheat (*Eriogonum* spp.), Mormon tea (*Ephedra* spp.), rabbitbrush (*Chrysothamnus* spp.), sagebrush (*Artemisia* spp.) and grasses such as galleta grass (*Pleuraphis jamesii*) and Indian ricegrass (*Achnatherun hymenoides)*.

The Grassland communities are found on deeper sandy soils which are derived primarily from sandstones. They include the grasses *Aristida* spp., *Pleuraphis jamesii*, *Muhlenbergia pungens*, *Bouteloua gracilis*, *Achnatherun hymenoides*, *Stipa comata*, and a variety of forbs, cacti and low shrubs.

The Upland Shrub communities are dominated by blackbrush (*Coleogyne ramosissima*), Mormon Tea (*Ephedra* spp.), sagebrush (*Artemisia* spp.), rabbitbrush (*Chrysothamnus* spp.), greasewood *(Sarcobatus vermiculatus*) and saltbush (*Atriplex* spp.).

The pinyon (*Pinus edulis*) / juniper (*Juniperus osteosperma*) woodlands occupy a range of sites with juniper dominating lower elevation sites and pinyon the higher sites. These communities are often associated with diverse understories of various grasses and shrubs including most of those previously mentioned for the grassland and upland shrub communities.

Upland Forest and Woodland Communities are dominated by ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*) with various understories including bitterbrush *(Purshia tridentata*), manzanita (*Arctostaphylos patula*), dogwood (*Cornus stolonifera*), and Rocky Mountain juniper (*Juniperus scopulorum)*. Other tree species include bristlecone pine (*Pinus longaeva*) and aspen (*Populus tremuloides*), both of which form unique restricted higher elevation more mesic communities.

The riparian and wetland communities occur around water sources. Tree species include box elder (*Acer negundo*), Fremont cottonwood (*Populus fremontii*), alder (*Alnus tenuifolia*), river birch (*Betula occidentalis*), and single leaf ash (*Fraxinus anomala*). The understory includes rabbitbrush, saltbush, cacti (*Opuntia* spp.) and grasses such as *Sporolobus contractus*, *Achnatherun hymenoides* and *Muhlenbergia asperifolia*. A detailed listing of plant vegetation in the Park is given by Romme et al. (1993) and Heil et al. (1993) as well as NPFlora. Lichens are abundant as with other parks of the Colorado Plateau and are listed in NPLichen.

Cole (1992) used packrat middens to reconstruct the patterns of vegetation over the past 5400 yrs in Capitol Reef National Park. He concluded that pre-European settlement vegetation was dominated by winterfat (*Eurotia lanata*), Indian ricegrass (*Achnatherun hymenoides*), pinyon pine, and sagebrush. Grazing over the past 100 years produced more severe changes in vegetation than at any other time in the 5000 yr history, shifting to dominance of rabbitbrush, greasewood, and snakeweed. Fisher et al. (1995) used opal phytoliths (small silicaceous granules with characteristic shapes among species) buried in soils to reconstruct vegetation over the past 800 yrs at Capitol Reef National Park. They concluded that ancient communities contained more forbs and shrubs, and that the grass communities were dominated more by cool season (C3) grasses than by warm season (C4) grasses. The period covered by these buried deposits was cooler than present, with likely greater summer moisture that would favor warm-season grasses. Fisher et al. (1995) attribute the shift to warm-season grasses as an indicator of overgrazing because historic grazing used the area in the early season when cool-season grasses were impacted more severely than warm-season grasses that grew primarily after cattle were removed for the season.

The plant species in Capitol Reef listed as endangered are Jones cycladenia (*Cycladenia humilis* var. *jonesii*), Maguire daisy (*Erigeron maguirei* var. *maguirei*), Barneby reed (*Schoencrambe barnebyi*), Wright fishhook cactus (*Sclerocactus wrightiae*), and last chance Townsendia (*Townsendia aprica*) (Heil et al. 1993; Threatened and Endangered Species Information Institute 1993). Species of concern to the NPS include: Ute ladies' tresses (*Spiranthes diluvialis;* Heil et al. 1993), *Gilia caespitosa*, *Pediocactus winkleri, Cymopterus beckii*, *Dalea flavescens* var. *epica*, *Erigeron maguirei* var. *harrisonii*, *Habenaria zothecina*, *Hymenoxys depressa*, and *Thelesperma subnuda* var. *alpina*.

Air Quality

Air quality monitoring for Capitol Reef National Park consists of ozone concentrations for the summer of 1995 and 1996 (passive collector), and NADP monitoring from Green River, Utah from 1982 to the present. No information is available for sulfur dioxide, particulate concentrations, or visibility. We expect the regional values for this area to resemble Bryce Canyon, Arches, and Canyonlands National Park.

Emissions

Table 8-1 provides summaries for emissions of carbon monoxide (CO), ammonia (NH_3), nitrogen oxides (NO_x), volatile organic compounds (VOC), particulate matter (PM), and sulfur oxides (SO_x) for 8 counties surrounding Capitol Reef National Park. The largest sources of SO_x in Emery and Carbon Counties in Utah come from three Pacificorp plants (Huntington, Hunter, and Gate). No local information is available to relate these emissions to air quality at Capitol Reef, or to apportion air quality impairment at Capitol Reef National Park to local and regional sources. However, the work by Eatough et al. (1996) to apportion SO_x sources for Canyonlands National Park and Green River, Utah probably relate to Capitol Reef. Eatough et al. (1996) apportioned the SO_x in Canyonlands to emission sources over a 3-month period from January through March in 1990, based on "fingerprints" of ratios of compounds in the air, and air mass trajectories. For example, emissions from 2 coal-fired power plants had high ratios of spherical aluminosilicate particles to sulfate, but very low ratios of arsenic to sulfate. Air from Arizona was characterized by low ratios of these aluminosilicate particles to sulfate, and high ratios of arsenic to sulfate. They concluded that SO_x in Canyonlands National Park derived from a wide range of regional sources rather than from a dominant source; about 37% (during a 21 day period) came from the southwest, 20% from the south/southeast, 19% from the north/northeast, and 23% from the northwest. Eatough et al. (1996) concluded that the major sources of SO_2 were from the southwest, while major sources of particulate sulfate were from the southeast. To the northwest at Green River, Utah Eatough et al. (1996) found that a larger portion of the SO_x came from the southeast, and substantially less from the Utah Power and Light (now Pacificorp) generating stations to the North in the Green River Basin.

Table 8-1. Emissions (tons/day) for counties surrounding Capitol Reef National Park (Radian 1994).

County	CO	NH_3	NO_x	VOC	PM	SO_x
Emery, UT	40.49	0.70	114	56	273	51.73
Garfield, UT	13.69	0.60	1.46	63	253	0.22
Kale, UT	14.88	0.26	1.59	44	114	0.21
Piute, UT	4.59	0.35	0.51	9	8	0.06
San Juan, UT	40.75	0.66	3.87	103	405	0.45
Sanpete, UT	41.63	1.81	5.34	20	72	1.13
Sevier, UT	36.47	1.06	4.79	24	58	1.25
Wayne, UT	6.34	0.62	0.74	30	122	0.11

Air Pollutant Concentrations

Ozone concentrations in the summer of 1995 averaged 41 ppb on a weekly basis, with a peak weekly average of 46 ppb. These concentrations fall at the bottom end of the range that may produce visible effects or growth effects on very sensitive species (see Chapter 2), but no reports of injury or growth effects have been noted. No information is available for SO_2, but the low values for the entire region indicate that levels at Capitol Reef National Park should be far below any threshold of plant sensitivity.

Atmospheric Deposition

The rates of atmospheric deposition for Green River, Utah (about 100 km northeast of Capitol Reef) are relatively low (Table 8-2). Precipitation pH averages about 5.2. Deposition of N averages about 1 kg N ha^{-1} yr^{-1}, which is slightly higher than the rate of S deposition. The deposition of both ammonium and nitrate showed significant increasing trends from 1985 through 1994. Ammonium-N deposition increased by about 0.04 kg N ha^{-1} yr^{-1} (r^2=0.53, p<0.02) while nitrate-N deposition increased at a rate of 0.03 kg N ha^{-1} yr^{-1} (r^2 = 0.44, p<0.04). However, the significance of these trends depends completely on the very low values for the first year of monitoring (1985) when data completeness averaged only 54%. Even if these values were doubled, we suspect the data would be unreliable, being far lower than any other year. We conclude that N deposition probably has not been increasing at Green River. Sulfate deposition showed no trend during this period. There is no evidence that such low levels of deposition pose any threat to plants (see Chapter 2).

Table 8-2. Atmospheric deposition for Green River, Utah (NADP). Note the values for N and S compounds include the whole molecule and not just the N or S atoms.

	Concentration (mg/L)			Deposition (kg ha^{-1} yr^{-1})				Conductivity	Precipitation
year	NH_4	NO_3	SO_4	NH_4	NO_3	SO_4	pH	(µS/mm)	(mm/yr)
1985	0.01	0.30	0.49	0.01	0.22	0.37	5.55	0.64	75
1986	0.17	1.19	1.36	0.31	2.10	2.40	5.78	1.57	177
1987	0.48	1.27	1.40	0.86	2.26	2.49	5.35	1.18	178
1988	0.48	1.75	1.47	0.63	2.30	1.94	5.22	1.42	132
1989	0.94	2.13	1.94	0.59	1.35	1.23	6.83	2.68	63
1990	1.00	2.04	2.17	0.66	1.35	1.43	5.82	2.40	66
1991	0.43	1.42	1.22	0.83	2.72	2.34	5.74	1.32	192
1992	0.90	1.50	1.54	1.50	2.51	2.58	5.90	1.54	167
1993	0.53	1.33	1.33	1.10	2.77	2.77	5.58	1.14	208

1994	0.40	1.35	1.05	0.61	2.06	1.60	5.44	1.45	150

Sensitivity of Plants

No signs of air pollution injury have been reported for vegetation in or near Capitol Reef National Park. Only a few of the Park's species have been tested under controlled conditions for sensitivity to pollutants, and none of these tests included genotypes representative of the plants in the Park. Based on the ozone concentrations required to affect very sensitive plants, we expect that current ozone exposures could be high enough to affect some species. Current levels of ozone are probably too low to affect the conifers, and levels of SO_2 are far below any demonstrated threshold of sensitivity for any plants. In the absence of empirical evidence of any effects, no substantial problem is likely.

Water Quality and Aquatic Organisms

Water resources in Capitol Reef include the Fremont River, perennial, intermittent, and ephemeral streams and numerous springs. Water quality data from EPA's national data bases were retrieved for sampling sites in the park (NPS 1994). In general the pH range for permanent waters in Capitol Reef was 6.5 to 9.0; the highest values came from the Fremont River.

Lafrancois (1995, 1996) examined pools sitting on bedrock and in wetlands from 1993 to 1994. These are a subset of the more than 460 rock pools found along the Waterpocket Fold, most of which occur on sandstone outcrops. The rock pool biological communities included 53 species of macroinvertebrates and anurans. Two insect species, *Notonecta kirbyi* and *Rhantus gutticolis*, were significantly more abundant in wetland pools. The biggest determinants of species abundances in these rock pools were physical factors: flooding of the pools and evaporation of the pools as the summer season progressed.

The chemistry of rock pools in Capitol Reef was studied at three locations in the Park: Cottonwood Tanks, Muley Tanks and Fountain Tanks (located from north to south in the park). The range of pH in these tanks was 7.0 to 7.6, with very high ANC ranging from about 500 μeq/L to about 1230 μeq/L (Table 8.3). Compared to the two more northern sites, the Fountain Tanks rock pools had significantly higher concentrations of ANC, silica, conductivity, sulfate, and base cations.

This appears to be the result of differences in bedrock minerology. The relatively high pH and ANC values for these rock pools indicate high resistance to acidification; the sandstone substrate for these pools is more able to buffer acidic inputs. There is no information on whether deposition of N in major storms could affect these pools, especially in relation to allochthonous inputs of organic material.

Table 8-3. Water chemistry from tanks in Capitol Reef National Park (J. Baron, unpublished data).

Parameter	Cottonwood Tanks	Muley Tanks	Fountain Tanks
pH	7.0	7.3	7.6
Conductivity µS/cm	53	62	115
Calcium, mg/L	7.7	8.7	21.0
Magnesium, mg/L	1.4	1.6	3.3
Sodium, mg/L	0.4	0.4	0.8
Potassium, mg/L	1.3	1.7	1.1
Ammonium-N, mg/L	0.3	0.4	0.1
Chloride, mg/L	0.6	0.7	1.1
Nitrate-N, mg/L	0.1	0.1	0.1
Sulfate-S, mg/L	0.7	0.4	1.2
Phosphate-P, mg/L	0.0	0.0	0.0
ANC, µeq/L	503	555	1227
Silica, mg/L	0.8	0.5	1.4

Recommendations for Future Monitoring and Research

General recommendations for NPS Class I areas of the Colorado Plateau are presented in Chapter 14, and many of these apply to Capitol Reef National Park. Air quality is not monitored at Capitol Reef National Park, although information from Canyonlands NP, Bryce Canyon NP and other sites provides an approximate picture of air quality at Capitol Reef NP. Installation of a full IMPROVE site would not be warranted, but we recommend smaller scale, on-site monitoring of visibility and ozone.

The pothole aquatic ecosystems in the Park appear to be very well buffered with respect to acidification, and we have no recommendations for further research on acidity features; some monitoring may be useful. We do not know enough about the biogeochemistry of these systems and their watersheds to conclude that deposition of N and S species will not change both the chemistry and the biota of these unique systems. If funds are available, we recommend that time series data on chemistry of selected system be collected, with emphasis on the period following intense rain storms that could flush accumulated dry deposition into the pools. Chemical parameters to be monitored include: pH, ANC, ammonium, nitrate and sulfate. Analysis for sulfur isotopes could provide information on the source of the sulfate in pools (e.g. power plants, smelters). Manipulation experiments could be conducted on adjacent lands in similar types of aquatic systems. These experiments could include the additional of S and N compounds to either the rock pools or the watersheds of these pools to measure changes in surface water chemistry and biota.

Park Summary

Without substantial monitoring information, the status of AQRVs at Capitol Reef can only be inferred from the general picture across the Plateau. Visibility is currently the only AQRV known to be impacted by pollution in other Class I NPS areas of the Colorado Plateau. Current levels of pollution in southern Utah are probably high enough to produce haze and obscure the important vistas of the Park and surrounding areas. Any increase in aerosols would undoubtedly impair visibility further; substantial reductions in aerosols would probably be needed to restore pristine conditions at Capitol Reef National Park.

Little information has been collected on air pollution effects on the Park's biota. No sign of air pollution impacts on plant or animal species has been reported; ozone concentrations are high enough that some impact is possible for sensitive plants, but SO_2 concentrations are too low to affect plants.

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